Elie Metchnikoff.

Life of Elie Metchnikoff, 1845–1916. By Olga Metchnikoff. Authorised translation from the French. Pp. xxiii + 297. (London: Constable and Co., Ltd., 1921.) 21*s*. net.

IN an introductory chapter Madame Metchnikoff relates how, some years ago, one who scarcely knew her husband had asked permission to write his biography. Metchnikoff wanted his biography written, for he held that the story of the evolution of a mind and character in relation with its environment, if faithfully set down by one knowing and comprehending, is always an interesting psychological document. The idea of the story of his life being related by one who neither knew nor understood was, however, repugnant to him. So it came about that Madame Metchnikoff undertook the biography of her husband with his co-operation and on the understanding that the whole was to be told without reservation. The result, as Sir Rây Lankester observes in an appreciative preface to the English edition, is "a remarkable and beautiful record of the development and activities of a great discoverer."

Metchnikoff was born in 1845 in the province of Kharkoff, where he was educated first at the lycée and then at the university. The lycée is represented as a progressive school, and the sketch of the youthful Metchnikoff and his companions affords an interesting glimpse of the intellectual awakening of young Russia at this period. Among the books he read at fourteen years of age was Buckle's "History of Civilisation," and we gather from the biography that the idea of the dependence of human progress upon science originated from reading that work. This belief became strengthened as he grew older, and ultimately it reached the intensity of a religious faith. At fifteen years of age Metchnikoff abandoned the religion in which he had been brought up, and so ardently preached atheism to his fellow-pupils that he received the nickname "God is not." Although he appears to have devoted most of his time at school to reading books on science, religion, and philosophy, he nevertheless passed out from the lycée with the highest honours and entered the university. This is described as a stagnant and reactionary institution. His teachers were uninspiring, and exerted little influence upon him.

While at the university, however, he read "The Origin of Species," which he had brought back with him from a visit to Germany. Metchnikoff was fascinated by the splendour of the horizon it opened, and considered it had more influence upon his later career than any other book he read. He seems to have planned to devote himself to searching for further support of Darwin's great generalisation. With this object he decided to undertake the study of intermediate types with a view to disclosing the genetic relationships between different orders of animals.

This programme could not be carried out at his own university, so as soon as his undergraduate career was completed he went to Germany. Afterwards he removed to Naples, where he met Kowalevsky. Both young men became engaged in a comparative study of the embryology of invertebrates. Metchnikoff discovered embryonic layers similar to those of vertebrates in Arthropoda and Cephalopoda, thus helping to bridge the gap between the higher and lower animals.

It was at Giessen in 1865 that intracellular digestion by the cells of the alimentary canal of a land-planarian (*Geodesmus bilineatus*) was observed. It is explained that this was the first time that he had encountered this phenomenon except in protozoa and very simple metazoa. He was much impressed, and afterwards regarded the observation as the basis of his phagocytic theory, although at the time its full significance was not appreciated.

Returning to Russia full of enthusiasm for science, Metchnikoff was appointed a *docent* at Odessa, but, finding the university backward and reactionary, he removed to St. Petersburg, where he hoped to find conditions for work more congenial. He was, however, disappointed. There was no laboratory for him to work in, his time was consumed by teaching for a subsistence, his eyes became troublesome and his health bad. He was lonely, and during an illness he was nursed by a young lady in the house of a mutual friend. Craving for affection and sympathy, he not unnaturally became engaged to be married.

Unfortunately, the lady was phthisical and developed alarming symptoms immediately after marriage. The next few years are described as a tragic struggle against disease and poverty. The serious affection of his eyes prevented the use of the microscope, and his young wife's health became so precarious that he was obliged to resign his appointment and take her to Madeira, where she died.

After his wife's death Metchnikoff started on the return journey to Russia in blank despair, and, seeing no issue to his situation, attempted suicide at Geneva. Fortunately, he took too large a dose of morphia, was violently sick, and recovered.

On his return to Russia Metchnikoff was appointed to the chair of zoology at Odessa, which he occupied for nine years. He threw himself with enthusiasm into the duties of his post. At Odessa he met Madame Metchnikoff, who was then a schoolgirl. Finding that she was interested in zoology, he undertook to teach her, and shortly after they married. His second marriage was a happy one; his wife, although more directly interested in art than in science, became a willing disciple. Madame Metchnikoff thus describes their work together:—

"It was both delightful and profitable to work with him, for he opened out his ideas unreservedly and made one share his enthusiasm and his interest in investigations; he could create an atmosphere of intimate union in the search for truth which allowed the humblest worker to feel himself a collaborator in an exalted task."

Metchnikoff appears to have exerted a great influence in the university, especially upon the young men, but was regarded with some suspicion by the authorities, owing to the independence of his ideas and the directness with which they were expressed. After the assassination of Alexander II. in 1881 the government of the university became more and more reactionary, and the independence of the university was threatened. Though not greatly interested in politics, Metchnikoff seems to have become unavoidably involved in these quarrels, and ultimately, finding the conditions intolerable, resigned.

His resignation of the Odessa chair and the circumstances which led to it preyed upon his mind. Another period of ill-health ensued associated with intense depression, during which suicide was again attempted. In order not to harrow his family by a suicide that was too obvious, and at the same time to put the occasion to the use of ascertaining whether relapsing fever could be transmitted by inoculation, he injected into himself some blood from a patient suffering from that disease. He had a prolonged attack of the fever, but this shock treatment cured his pessimism, and after his recovery he had a renascence of vital energy such as he had not enjoyed for years. Moreover, thanks to the inheritance of landed property, the Metchnikoffs were now in a position of modest independence and able to live where they liked. Accordingly in 1882 they repaired to Messina to take advantage of the opportunities for study afforded by the sea fauna of the Mediterranean.

It was at Messina, at Christmas of that year, that what Metchnikoff regarded as the great event of his scientific life occurred. It is described by him in his own words as follows:—

"One day, when the whole family had gone to a circus, I remained alone with my microscope, observing the life in the mobile cells of a transparent starfish larva, when a new thought suddenly flashed across my brain. It struck me that similar cells might serve in the defence of the organism against intruders. I felt so excited that I began striding up and down the room, and even went to the seashore to collect my thoughts.

"I said to myself that, if my supposition was true, a splinter introduced into the body of a starfish larva, devoid of blood-vessels or of a nervous system, should soon be surrounded by mobile cells, as is to be observed in a man who runs a splinter into his finger. This was no sooner said than done.

. . . . .

"I fetched some rose-thorns and introduced them under the skin of some beautiful starfish larvæ as transparent as water.

"I was too excited to sleep that night in the expectation of the result of my experiment, and very early the next morning I ascertained that it had fully succeeded.

"That experiment formed the basis of the phagocyte theory, to the development of which I devoted the next twenty-five years of my life.

. . . . .

"A zoologist until then, I suddenly became a pathologist."

It appears that the discovery of phagocytosis first disclosed to him the possibility of utilising his talents to intervene advantageously in human affairs. A moral purpose in life was found, and thenceforth Metchnikoff became an optimist and a scientific philanthropist. His future researches, although conducted in the laboratory, were essentially directed towards the improvement of the health and happiness of mankind. Possibly his scientific work suffered occasionally from his impatience to apply results to the benefit of his fellow-creatures. for, like most philanthropists, he exhibited some intolerance of criticism of his efforts.

In 1882 phagocytosis as a curative force was still only an hypothesis, but an opportunity for putting it to the test of experiment soon occurred. Water fleas (Daphniæ) were observed to be subject to infection by a fungus (*Monospora bicuspidata*) the spores of which, sharp like needles, traversed the gut of the insect when introduced with food. Watching the process in these transparent creatures, Metchnikoff saw that, immediately after the entrance of a spore into the body cavity, it was attacked by mobile phagocytes and englobed. If the phagocytes succeeded in digesting all the spores, the daphnia recovered, otherwise the spores germinated, and the fungus, spreading throughout the body, killed the insect. Recovery or death depended upon the issue of the battle.

The next question to be decided was whether this method of defence was common to all animals. That some diseases of higher animals were attributable to invasion by microbes had recently been established, and it is explained how Metchnikoff's previous training and experience as a zoologist had led to the conviction of the essential unity of structural plan and physiological behaviour throughout the animal kingdom. Metchnikoff was convinced that in the case of such a fundamental mechanism as that he had discovered in invertebrates this would prove to be true, and shortly afterwards he succeeded in establishing the generality of the phenomenon by experiments upon higher animals infected with the anthrax bacillus. In this case the bacilli were attacked and eaten by the white blood corpuscles which wander everywhere. Two other observations recorded deserve special mention because they opened up new country, the exploration of which occupied Metchnikoff and his pupils and many others for the next twenty years.

The first of these was that active phagocytosis occurred only in animals refractory to anthrax, thus providing a possible interpretation of the natural immunity of some species of animals to a disease. The second was that animals naturally sensitive to anthrax could be induced to respond like naturally refractory ones by vaccination, an indication of the nature of acquired immunity.

Such entirely new conceptions were not readily acquiesced in, and even encountered hostility. Two great men, Virchow and Pasteur, however, were immediately impressed by them, and in 1888 the latter invited Metchnikoff to come to the Pasteur Institute. The invitation was accepted, and there he remained until the end of his life, occupied under ideal conditions in developing the consequences of his discovery at Messina.

At the Pasteur Institute he found every facility for his researches, and was undisturbed by administrative or academic work. He enjoyed the companionship of wise colleagues, themselves actively engaged in inquiries in bacteriology and pathology, and soon became surrounded by willing pupils ready to undertake investigations dictated by his fertile imagination.

This was a time of immense activity, mainly devoted to exploring the whole subject of immunity which he had illuminated by the discovery of phagocytosis. This prolific period of his career is skilfully dealt with in broad outline, and details which, being of a highly technical character, would be tiresome to the general reader are omitted. The theories current regarding immunity when Metchnikoff approached the subject from a naturalist's point of view are briefly sketched, and the influence of his work and that of others in the development of our present views is indicated.

In 1900 Metchnikoff presented an account of his researches to the International Congress of Medicine at Paris, and fought his critics for the last time. Then, convinced that his deductions were sound, he proceeded to expound his views at length under the title, "Immunity in Infectious Diseases," which appeared a few years later.

Metchnikoff's greatest scientific achievement was undoubtedly the discovery of phagocytosis and its manifold significance in biology and pathology, and it is clearly brought out in his biography that he would not have made these discoveries had it not been for his previous training and research in zoology. Perhaps the best way to appraise this, his contribution to science, is to try to think what our present knowledge of inflammation and immunity would be without it.

At the age of fifty-three Metchnikoff turned his attention to the subject of senility. Regarded from a long biological view, man's imperious instinct for life in the later years of existence, notwithstanding obvious breakdowns, must, he considered, be a pathological coincidence. How, otherwise, was the fear of death, a general and inevitable occurrence, to be explained? Metchnikoff imagined that this lack of harmony exists because senility is premature and partial and arrives before the natural instinct for death has had time to develop.

If this supposition were correct, the greatest of life's disharmonies might be remedied, for he believed that it was within the power of science not only to preserve the body from the depredations of disease, but also to maintain the equilibrium of the tissues. In such a case happiness and contentment should be the lot of man for a period far exceeding the usually allotted span. Upon such ideal physiological existence or "orthobiosis" a quiet satiety with living should, he supposed, ultimately supervene and death be welcomed as sleep at the end of a long day.

The consideration of the changes in the tissues in old age led Metchnikoff to the conclusion that, apart from the damage done by diseases such as syphilis, tuberculosis, and other chronic infections, the principal cause of premature degeneration of the important cell elements was a prolonged intoxication by the products of the activities of the innumerable bacteria which inhabit the large intestine. For this hypothesis he obtained anatomical and experimental support.

The former he tersely summarised by the phrase, "the longer the large intestine, the shorter the life," an aphorism which is to some extent responsible for the depredations of some of our famous surgeons.

Having arrived at the conviction that unlicensed bacterial activity in the colon was harmful, Metchnikoff essayed to control it by implanting into the alimentary canal a special microbe which produced much lactic acid from carbohydrates, and was itself capable of surviving in high concentration of this acid. To this end he recommended, and himself practised, the imbibition of large quantities of soured milk.

Metchnikoff's preoccupation with the disadvantages of senility have been misunderstood and misinterpreted. Although his attention was becoming unpleasantly directed in his own person to the effects of a life of intense activity and mental excitement, coupled with serious cardiac mischief, it is not to be ascribed to the morbid introspection of an invalid. Old age is a legitimate subject for scientific inquiry. It is not unnatural, but unfortunate, that nobody becomes sufficiently interested in the problems of senility until their own age well-nigh precludes the possibility of a successful enterprise. It was approached by Metchnikoff with ideas based on broad biological principles, and most of his late work was really concerned to find justification for them.

Elie Metchnikoff's enthusiasm for his theory of orthobiosis was maintained actually until the end of his life, and the last chapter of the biography contains many records of his mental attitude on contemplating death at short range. He was anxious that these should be recorded as so few with the capacity to analyse their mental processes retain their intellectual powers until the end of life.

His wishes have been piously complied with, and his observations, when confronted with impending dissolution, are faithfully recorded as his final contribution to his theory of the development of the death instinct.

The book is more than an account of the interesting discoveries of Elie Metchnikoff and their far-reaching importance in natural history; it is a human document, an account of the mental adventure of a striking personality, with contemporary science as a setting, told with a *naïveté* reminiscent of Marie Bashkirtseff.

The translation is excellent, and little if any of the charm of the original French is lost. The biography contains as frontispiece a characteristic picture of Metchnikoff in his laboratory, and concludes with a useful bibliography of all his published writings.

Electrical Measurements.

Absolute Measurements in Electricity and Magnetism. By Prof. A. Gray. Second edition, rewritten and enlarged. Pp. xix + 837. (London: Macmillan and Co., Ltd., 1921.) 42*s.* net.

ALL physicists are familiar with the first edition of this important work, which, completed in 1893, has long been regarded and used as a standard treatise on electrical measurements. In introducing the second edition Prof. Gray refers at the outset to a certain lack of interest shown by physicists at the present time in the theory and practice of absolute measurements, and it is undoubtedly the case that, in our universities at any rate, the subject receives less attention than was formerly devoted to it. The principal reason for this change may be traced to the nature of such work as the experimental determination of absolute electrical units, and the accurate comparison of secondary standards with them, and also to the great importance which work of this kind possesses. Few, if any, of our university laboratories are sufficiently well equipped for the prosecution of researches in which the construction of apparatus and the carrying out of measurements of the highest precision are involved; and so necessary is this work recognised to be that special laboratories, such as the National Physical Laboratory in this country, and the Bureau of Standards at Washington, have been established, at which it can be more effectively organised and carried out, and at which the research worker in any of the universities may have his measuring instruments accurately standardised. Thus the apparent decline of general interest among physicists in methods of absolute measurement is not due to any diminution in the importance of the subject, but to the fact that the practice of these methods is now more concentrated in institutions specially equipped for the purpose.

A second reason for the change may be found, as suggested by Prof. Gray, in the fact that new and fascinating subjects of study, mainly consequent upon the discovery of the X-rays and radio-activity, have arisen which have been taken up with enthusiasm in our universities, and have to some extent diverted attention from absolute measurements of the classical kind. While it is of the greatest importance that research into the problems of modern physics should be pursued as vigorously as possible, it is no less important to the future of the science that the endeavour to attain greater accuracy in our standards and methods of measurement should not be relaxed. It may well be that the future trend of physical theories will be largely influenced by the degree of accuracy with which some of the important constants can be determined.

The new edition of Prof. Gray's book will be welcomed as a full and clear statement of the present position regarding accurate electrical measurements. There is probably no other book which contains so full an account of the classical experiments for the determination of electrical units and constants, and the many detailed abstracts of original memoirs give the book a special value as a work of reference.

The principal changes found in the new edition